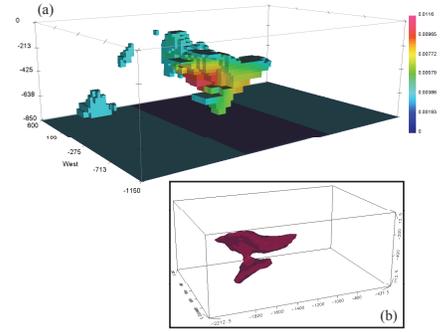


# Detailed update summary: MAG3D v5.0



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## Overview

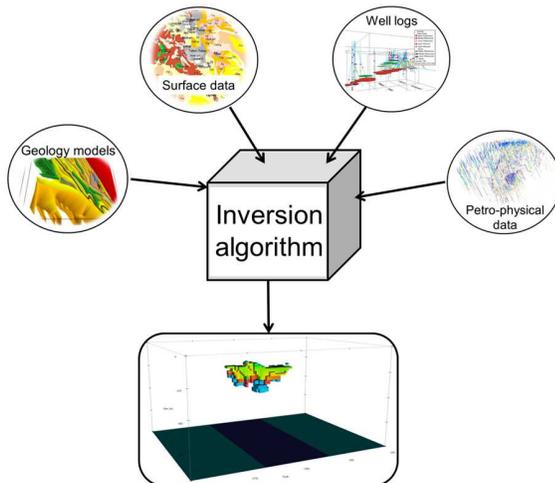
MAG3D v5.0: A program library for carrying out forward modelling and inversion of surface, airborne, and borehole magnetic data. Significant upgrades reduce computation time through parallelization and increase the flexibility to incorporate geologic information have been made.

## Background

UBC-GIF inversions solve the inverse problem by minimizing a global objective function

$$\begin{aligned} \min \phi &= \phi_d + \beta \phi_m \\ \text{s.t. } \kappa^l &\leq \kappa \leq \kappa^u \end{aligned}$$

created from the combination of a data misfit term,  $\phi_d$ , (quantifying the reproduction of the observed data) and model objective function,  $\phi_m$ . The latter gives the user a unique opportunity to include other geological, petrophysical, and geophysical information into the inversion framework. The trade-off parameter  $\beta$  balances the data fit and model smoothness. Lower ( $\kappa^l$ ) and upper ( $\kappa^u$ ) bounds can be also be specified throughout the model region.



## Parallelization

The forward modelling and sensitivity calculations have been parallelized using OpenMP. The time required to calculate the sensitivity matrix decreases linearly with the number of processors. The inverse calculation time reduced slightly. Note that times vary based on problem specifics and computer performance.

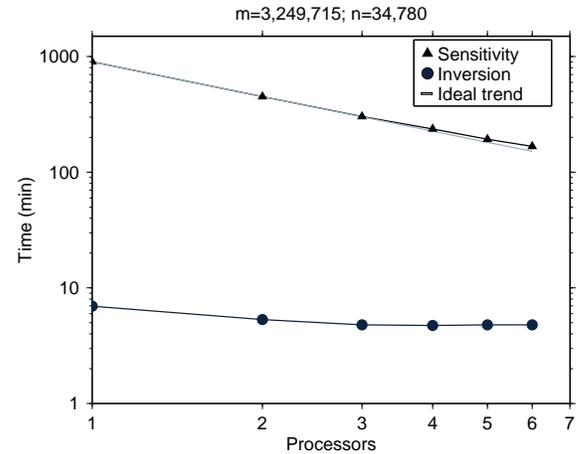


Figure 1: Computation time vs number of processors (threads). Number of cells: 3,249,716; number of data: 34,780. Processing done on a PC with 3.2 GHz Intel Core i7 790 with six dual-core processors.

# of Cores	Sensitivity	Inversion	Linear trend
1	902.30	6.94	902.30
2	452.29	5.33	452.29
3	303.10	4.80	301.97
4	237.03	4.72	226.71
5	192.75	4.79	181.52
6	167.08	4.78	151.37

Table 1: Number of CPU cores versus time (sec) of calculations.

# Incorporate geologic information

## Drill-hole constraints:

- Information is incorporated as upper and lower bounds with the projected-gradient method (Vogel, 2002), allowing the recovered model to reach the bounds, and
- Propagation of the model away from the constraint location can be smooth. A model that is laterally smooth away from the borehole can be constructed as long as it is compatible with the data.

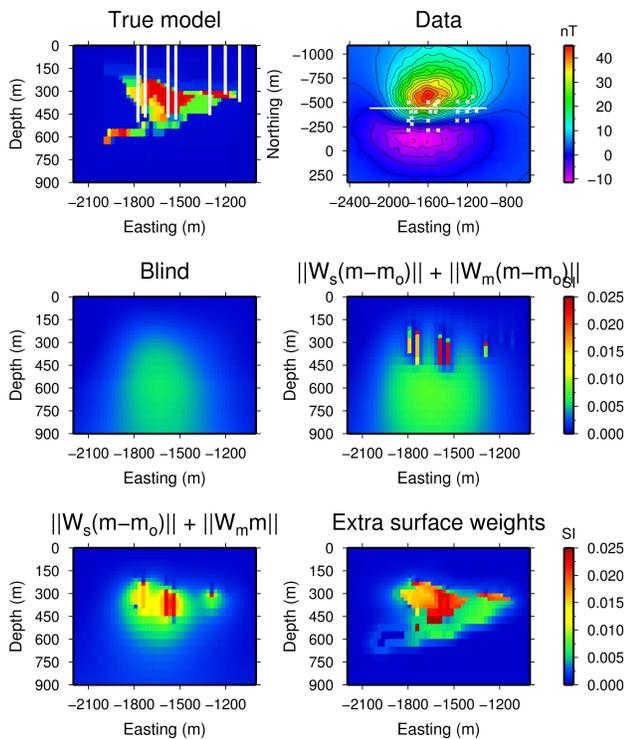


Figure 2: Cross-sections of recovered models: the true with drill hole locations (top left), emphasis on the gradient of the reference model (middle right), and with emphasis on only the value of reference model (bottom left). The data are shown in the top right; the  $x$ 's denote horizontal locations of the drill-holes and the line shows the location of the cross-sections.

*Reference models:* Previously assumed geologic structure can be incorporated through reference models and/or weighting matrices.

*Inactive and active cells:* Particular cells, or regions of the model, may be held fixed during the inversion. This reduces the size of the problem and provides an alternative method for incorporating prior information.

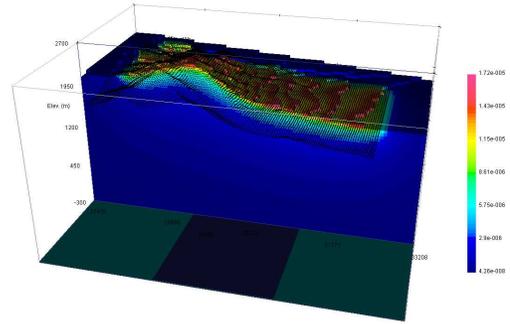


Figure 3: Average sensitivity for each cell.

## Output files

*Additional files:* The average sensitivity for each cell is written out as well as depth weighting or distance weighting files. These can help in survey design or depth of investigation, particularly in areas of high topographic relief.

*Simplified log files:* Output log information has been simplified for easier analysis. An additional “developers” log has been created to record inversion details for the advanced user.

## Maintenance and future releases

MAG3D v5.0 is released with a maintenance agreement that includes support for carrying out the inversions as well as receiving upgrades for the software. Planned improvements for MAG3D include:

- Further flexibility in incorporating geologic knowledge and petrophysical constraints,
- Optional automatic removal of DC bias in the reduced magnetic data,
- Robust norms for evaluating misfit, and
- Further improvements in computation speed.

## Contact information

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